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The Early U.S. Space Program

In early 1958, when the Soviet Union and the United States had each launched two satellites, it was obvious, from comparing their weights, that the Soviets were using a much more powerful launch vehicle. This led to great concern in the United States about the apparent lag in vehicle capability—a concern welcomed by space enthusiasts for it meant more support. This concern, however, was not entirely justified when all the technological gains associated with the development of intercontinental and intermediate range ballistic missiles are considered. Indeed, modifications of these vehicles provided the base for the U.S. "stable" of launch vehicles in the early years of the space program. One ICBM, the Atlas, established the feasibility of lightweight, pressure-stabilized tanks, a technology important for favorable consideration of low-density liquid hydrogen. For all these reasons, a review of the development of Vanguard, the first U.S. vehicle developed solely as a launch vehicle, and military ballistic missiles during the 1950s is helpful in understanding launch vehicle planning during 1958 and 1959.

The Navy's Vanguard

When the National Security Council endorsed the concept of a scientific satellite in May 1955, it was based on two conditions: peaceful purposes were to be stressed and no interference with the development of ballistic missiles was to be permitted.[1] Donald A. Quarles, Deputy Secretary of Defense, charged with selecting a suitable vehicle for the scientific satellite, appointed a committee headed by Homer Joe Stewart, a rocket expert at the Jet Propulsion Laboratory and professor at the California Institute of Technology. The Stewart committee recommended a vehicle proposed by the Naval Research Laboratory. It consisted of a Viking first stage,* a second stage using liquid propellants, and a third stage using solid propellants. A modification of this combination became the Vanguard launch vehicle, and the Navy managed its development.

*Viking, built by the Glenn L. Martin Co., was powered by a Reaction Motors rocket of 89 kN (20 000 lb thrust) and used alcohol and liquid oxygen as propellants.

Vanguard was a slender vehicle, 21 meters tall and 1.1 meters in diameter, weighing 10250 kilograms at launch. The first stage was powered by a General Electric X-405 rocket engine of 120 kilonewtons (27000 lb thrust) using kerosene and liquid oxygen. The second stage was powered by an Aerojet rocket engine of 33.4 kilonewtons (7500 lb thrust) using a hydrazine compound (unsymmetrical dimethylhydrazine—UDMH) and nitric acid as propellants. The third stage was driven by a solid propellant rocket of 13.8 kilonewtons (3100 lb of thrust).[2]

Vanguard development was treated like a second-class program from the start, particularly when it came in conflict with high-priority ballistic missile programs. Even the funding was second level, coming from an emergency fund of the Secretary of Defense for two years. By the spring of 1957, however, development was proceeding satisfactorily. Two successful test flights had been made and the third (TV-2*), with a live first stage and dummy upper stages, was on schedule. Confidentially, the Navy ordered Glenn L. Martin to make the remaining test vehicles with live upper stages and capable of launching a satellite. In the months that followed, however, the Vanguard team encountered problems and was still struggling to patch and fly TV-2 when Sputnik was launched.

The Vanguard team then found itself suddenly in the spotlight. John Haugen, the quiet, scholarly Vanguard director, briefed President Eisenhower. John Hagerty, the White House press secretary, relying on the optimistic part of Haugen's briefing, announced five days after Sputnik that the first of a series of test vehicles carrying a small satellite sphere would be launched in December 1957. Although Hagerty added that the first fully instrumented satellite would be launched in March 1958, the media emphasized the December date as the time the U.S. would match the Russian accomplishment. The Vanguard team finally launched the recalcitrant TV-2 successfully in October and on 6 December prepared to launch the three-stage TV-3. A large gathering of reporters and spectators saw TV-3 rise from the pad about a meter, fall back, and collapse into a giant fireball.[3] That was the low point in the trouble-filled Vanguard development. Success came on 17 March 1958 when Vanguard I launched its tiny but well-instrumented satellite which transmitted signals for seven years. Meanwhile, a U.S. Army team, under the technical direction of Wernher von Braun, had launched the first American satellite.

The Army's Redstone and Jupiter Vehicles

The Army's principal missile team was formed around 120 German rocket experts brought to the United States in 1945. First stationed at Fort Bliss, Texas, the Germans were transferred to the Army's Redstone Arsenal, Huntsville, Alabama, in 1950; and they were soon deeply involved in the Army's growing missile development program. The technical group was headed by Wernher von Braun, who had held the same position at Peenemünde during the development of the German A-4 (V-2) rocket, the beginning of modern rocketry.[4]

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*TV-2 was the second of the Vanguard test vehicles; the earlier two vehicles flown were a leftover Viking and TV-1.

The first large Army ballistic missile was the Redstone, modeled after the V-2. Redstone was powered by a North American Aviation rocket engine developing 334 kilonewtons (75000 lb thrust) using an alcohol-water mixture and liquid oxygen. During eight years of research and development and 37 flights, the Redstone evolved into a 322-kilometer-range vehicle, 21 meters tall, 1.8 meters in diameter, weighing 27670 kilograms at launch.[5]

A space enthusiast since youth, von Braun proposed a satellite launch vehicle based on Redstone in 1954, a year after the first Redstone launch. In 1955, his team submitted a proposal for a satellite launch vehicle to the Department of Defense. Called Jupiter C, it consisted of a modified Redstone with two solid-propellant upper stages. This design was used in a joint Army-Navy proposal to the Stewart committee, but it was not selected. Disappointed, von Braun soon found another application—study of aerodynamic heating of a warhead reentering the atmosphere during a ballistic trajectory. Three Jupiter Cs were launched, the last less than two months before Sputnik I. After this flight, the commander of the Army Ballistic Missile Agency (ABMA) at Redstone Arsenal, Maj. Gen. John Bruce Medaris, ordered the remaining Jupiter equipment into storage. As enthusiastic a space proponent as von Braun, Medaris was waiting for the right opportunity to show what ABMA could do in spaceflight.[6]

The perfect opportunity soon came. Medaris and von Braun were dinner hosts to visiting Neil McElroy, who was succeeding Charles Wilson as Secretary of Defense, when word came that Sputnik I was launched. The rest of the evening and the following morning were devoted to what ABMA could do. On 31 January 1958, the Medaris-von Braun team launched Explorer I, first American satellite, using a modified Jupiter C vehicle.*

The Air Force and the Ballistic Vehicle Build-Up

Although the Army had shown great initiative in ballistic missile development, the Air Force became the dominant military service in long-range, ballistic missiles. The Air Force had the responsibility for developing the Atlas and Titan intercontinental ballistic missiles (ICBM), the Thor intermediate range missile, and later, the Minuteman, an all-solid-propellant missile.

The Atlas and Titan had a range of about 10000 kilometers and a payload capability of 700 kilograms. The Atlas was powered by two 667-kilonewton (150000 lb thrust) first-stage engines plus a 267-kilonewton (60000 lb) sustainer engine. At launch, all three engines operated and at the end of first-stage operation, the two large engines were jettisoned leaving the sustainer engine to continue to operate during the second phase. Propellants for all three engines came from common tanks which constituted the bulk of the structure. These tanks were made of thin-gage stainless steel and depended upon internal pressure for structural stability. Since Atlas jettisoned only its first-stage engines, it was called a 1½ stage vehicle. Titan I, on the other hand, was a

*It consisted of a modified Redstone first stage and three upper stages of solid rockets. The three upper stages used 11, 6, and 1 Sergeant solid rockets, respectively. The Sergeant, 11 cm in diameter, was developed by the Jet Propulsion Laboratory, which teamed up with ABMA in building and launching the first satellite.

conventional two-stage vehicle which jettisoned both first-stage engines and associated tankage. Its tanks were of the more conventional design with internal ribs for structural stability. Titan I's engines were similar to those for Atlas, and both vehicles used a jet-grade fuel similar to kerosene, with liquid oxygen as oxidizer.*

The Atlas, developed by the Convair division of General Dynamics Corporation, is of special interest to our story.† As one of two contractors studying 8000 kilometer vehicles for the Air Force in 1947, Convair chose a ballistic missile over a winged, subsonic vehicle—a bold decision at the time. A key to long-range ballistic missiles was achieving very light structures and an imaginative Convair engineer, Karl J. Bossart proposed several bold innovations for light structures. By the end of 1948 and three test flights, Bossart was able to incorporate his innovations into the Atlas design. One was the use of integral, thin-wall, pressure-stabilized tanks previously mentioned. Although Oberth had proposed such balloon-like tanks in 1923 and both the Glenn L. Martin Company and North American Aviation had used the concept in satellite designs for the Navy (pp. 41, 44), such tanks had never been built and flown. Bossart had independently conceived the idea during design calculations when he found that the tank pressure needed for the inlets of the engine's pumps was greater than the internal pressure necessary for the tanks to remain stable under aerodynamic forces and vehicle loading. Bossart also dispensed with insulation for the liquid oxygen tank and used swiveling rocket nozzles to control the pitch, yaw, and roll of the vehicle during flight.[7]

Bossart's innovations and the initial Atlas project aroused little interest until the early 1950s when the Air Force swung away from air-breathing propulsion and winged missiles in favor of ballistic missiles. The break for Atlas came in 1954 when the Air Force Strategic Missiles Committee recommended that it be developed with some changes. The committee also recommended that a new management group be established to accelerate ballistic missile development. This resulted in the formation of the Ballistic Missile Division of the Air Research and Development Command under Brig. Gen. Bernard Schriever, and the ballistic missile program began to accelerate. In fiscal year 1953, funding was $3 million; in FY 1954, $14 million; in FY 1955, $161 million. In February 1955, another advisory committee recommended additional development of intermediate range ballistic missiles (IRBM) with a range of 2800 kilometers. By the summer of 1955, the Air Force had two ICBMs (Atlas and Titan) and one IRBM (Thor) under development. The Army won approval to develop the Jupiter IRBM.‡ The Navy turned to solid propellants and the Polaris missile was initiated. The Air Force also became interested in solid-propellant missiles and in 1957 began development of the Minuteman. During this period, funding continued to climb: in FY 1956, $515 million; in FY 1957, $1.3 billion.[8] Thus, by the time of Sputnik, six U.S. missiles were being developed with the highest national priority, and

*The later Titan II used storable propellants, UDMH and N_2O_4.

†Consolidated Aircraft became Consolidated-Vultee (Convair) in 1943 and was absorbed by General Dynamics in 1954. The division building rockets has been named Convair, Astronautics, and now Convair-Aerospace.

‡Jupiter, developed by the Chrysler Corp. for the Army, is not to be confused with Jupiter C developed in-house by ABMA.

all were larger and had greater payload capability than Vanguard. By 1958, development of liquid-propellant missiles not only provided the basic technology applicable to future launch vehicles but also the vehicles themselves were to become the greater part of the first generation of launch vehicles.

A key technology responsible for achieving low structural weight of the Atlas missile was Bossart's thin-gage, pressure-stabilized tanks. This concept met with considerable skepticism during the development of the Atlas. Opponents pointed out that if pressurization should fail, the tanks—and the missile—would collapse of their own weight. An equal concern was how well the tanks could withstand high aerodynamic loads during the early part of a flight. Doubt was sufficiently widespread that Titan, the second ICBM, was built with tanks of conventional design. An unanticipated severe test of the pressure-stabilized tanks came with the first test flight of Atlas in 1957. Hot exhaust from the turbopump burned through control wiring and the vehicle began to tumble while still in the atmosphere, placing excessive loads on the tanks. They held, and anyone viewing the film of the flight could easily become a convert to Bossart's concept. In spite of this, however, some engineers remained unconvinced, and prominent among them were those in the von Braun team.* This attitude was important to their later consideration of liquid hydrogen, as we will see.

During the build-up of missile capability in the 1950s, President Eisenhower and the Department of Defense kept booster programs closely related to surface-to-surface military requirements, much to the disappointment of space enthusiasts. A prevailing attitude was that spaceflight was not yet practical, and work to make it so was far too costly to be taken very seriously. To be sure, there was tolerance for research on high-energy propellants and other means for achieving high rocket velocities, but it was peripheral to the main task of developing long-range ballistic missiles. Up to the time of Sputnik, talk of spaceflight was very unpopular in the halls of government and proponents had to tread very lightly. "Space Cadets" were frowned upon and the use of the word "space" in a proposal in pre-Sputnik days invited budget cuts within the executive branch and in Congress.

Competition for the Space Role

Sputnik unleashed all the pent-up desires of U.S. space proponents in both the military and civilian sectors. The military advantages of satellites for reconnaissance and communications were obvious, but plans ranged far beyond these applications. For years the Air Force had quietly been preparing for manned flight into space. The Army was more aggressive, speaking of moon bases as the ultimate "high ground." The Army also had the superb missile development team of ABMA with over three

*Bossart and his colleagues at General Dynamics staged a demonstration in an attempt to show engineers from ABMA the toughness of the thin-wall tanks. They pressurized a discarded Atlas tank and invited one of the engineers to knock a hole in it with a sledge hammer. The blow left the tank unharmed, but the fast rebounding hammer nearly clobbered the wielder. In another instance, von Braun expressed his attitude towards the tanks during a good-natured exchange on using the Atlas for Project Mercury: ". . . John Glenn is going to ride on that contraption? He should be getting a medal just for sitting on top of it before he takes off!" Interview with K. J. Bossart, 27 Apr. 1974; group interview with Grant Hansen, K. E. Newton, Deane Davis, Donald Heald, and Bossart, Convair Aerospace Div., San Diego, 29 Apr. 1974.

thousand engineers and technicians to provide sound, detailed proposals. Maj. Gen. J. B. Medaris, ABMA commander, was a strong space advocate and had the backing of those above him, especially the blunt and aggressive Secretary of the Army, Wilbur Brucker. Navy space enthusiasts lacked high-level support, hence the Navy was not a strong competitor. The Air Force, with responsibility for intercontinental ballistic missiles, viewed space as a logical extension of its airspace. It was already skirmishing with the Army over the Thor and Jupiter IRBMs and this extended into their bid for a role in space.

With the big money in the military and their traditional role of spearheading costly flight developments, a strong civilian role in space appeared remote. Even the first scientific satellites were managed and controlled by the military, although the scientific community had access to the resulting data. Almost everyone assumed that the same arrangements would characterize future U.S. space efforts.

The only civilian government group seriously in the space role competition was the normally quiet and timid National Advisory Committee for Aeronautics (NACA), which had almost missed the boat on jet propulsion twenty years earlier. NACA had smart, eager young men as well as wise old officials, and some of both groups were determined not to miss the opportunities offered by space exploration. The NACA lacked the money and clout of the military services and traditionally cooperated with the military on expensive development projects, such as the X series of experimental aircraft. The military provided the funds, managed the development and initial operations, while the NACA provided the instrumentation and analyzed the experimental results. Eventually, the aircraft were turned over to NACA. In its first proposals for space exploration, NACA's director Hugh Dryden envisioned the same sort of working relationship, but both he and the military reckoned without the will of the ex-military man in the White House.

President Eisenhower was well aware of the interservice rivalries as well as the international implications of a peaceful effort for space exploration. In response to Sputnik, he had allowed the Army to proceed with a back-up to Vanguard, but he had not accepted the concept of a significant military effort in space. In November 1957, he appointed an old and trusted friend and advisor, James R. Killian, president of the Massachusetts Institute of Technology, to be his special assistant for science and technology. Killian and his science advisory committee played a key role in influencing the policy for space research during the months that followed. That policy turned in favor of a civilian space program.

Consolidation of Military Space Projects

In his 9 January 1958 State-of-the-Union message, President Eisenhower spoke of the need for a single focal point for advanced military projects, including anti-missile and satellite technology. Four days later, Secretary of Defense Neil McElroy told the House Armed Services Committee that he was establishing an Advanced Research Projects Agency (ARPA) responsible to him for anti-missiles and outer space projects. ARPA was formally established on 7 February with Roy W. Johnson, a former executive vice president of the General Electric Company, as the director and Rear Admiral John Clark as his deputy. A month later, Herbert F. York, director of the

Livermore Laboratory of the Atomic Energy Commission and associate director of the department of physics of the University of California, was appointed chief scientist. ARPA had authority over all military space activities.[9]

On 27 March, President Eisenhower approved ARPA's plans for space exploration as announced by Secretary of Defense McElroy. When a new civilian space agency was organized, it would take over the non-military space programs. ARPA's plans included earth satellites and space probes for scientific investigations, the latter as part of the International Geophysical Year program. Losing no time, ARPA authorized the Air Force Ballistic Missile Division to launch three lunar probes with Thor-Vanguard vehicles and the Army Ballistic Missile Agency to launch deep space probes with the new Jupiter IRBM equipped with the same cluster of solid rocket stages that had placed Explorer I in orbit. The original FY 1959 budget request of $340 million for ARPA was raised to $520 million.[10]

Not long after he went to ARPA, York met David A. Young of Aerojet and invited him to work with him. Young, who had worked with liquid hydrogen and oxygen in the late 1940s (p. 33), accepted.[11] He was among the first of a number of highly competent rocket and missile experts recruited for ARPA by Johnson, Clark, and York. These experts, hired and paid by the Institute of Defense Analysis, a private firm that provided technical and administrative services for ARPA, received the same salary as they did from their former employer. Young recruited Richard B. Canright from Douglas Aircraft, where he had been assistant chief engineer of missile systems. Prior to that, Canright had conducted research at the Jet Propulsion Laboratory of the California Institute of Technology on liquid and solid propellant rockets. Canright, a knowledgeable and experienced propulsion expert, was well familiar with hydrogen. He had operated a rocket on gaseous hydrogen and oxygen in the early 1940s (fn, p. 34) and wrote a paper in 1947 on the relative importance of specific impulse and density for long-range rockets (pp. 47–48). He and David Young were members of the NACA subcommittee on rocket engines and staunch supporters of the NACA high-energy rocket program. From the Air Force came dynamic and aggressive Richard S. Cesaro. He was recommended to York by Richard Horner, assistant secretary of the Air Force for R&D, and came to ARPA in June.[12] Cesaro, a long-time employee of NACA in propulsion research and committee management, had moved to the Air Research and Development Command headquarters in January and was the technical director for aeronautics and astronautics. Cesaro was a master at maneuvers in government decision-making processes, a technical gadfly, and an aggressive proponent for using advanced technology.[13]

By early June, a number of experts were working for ARPA and York assigned them to a number of ad hoc panels to plan and initiate military space programs.*

Canright organized an informal panel on vehicles and he persuaded some of his colleagues—Cesaro, Youngquist, Irvine, and Young—to serve on it. In mid-June 1958,

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*John F. Kincaid to solid propellant chemistry, Samuel B. Batdorf to man-in-space, Charles R. Irvine and Capt. R. C. Truax to Project 117-L, Arthur J. Stosick to large engines, David A. Young to communication relays, Roger B. Warner to meteorology, Richard B. Canright to scientific satellites, Col. Dent L. Lay to Project ARGUS, Robertson Youngquist to exploratory research, and Richard S. Cesaro to satellite tracking.

Canright and Young were asked by Johnson to present ARPA's plans to a panel of the National Security Council. Canright made two recommendations on vehicles and engines: use a cluster of proven rocket engines for large vehicles, and use hydrogen and oxygen as propellants in upper stages. To Canright, using multiple rocket engines for space vehicles was an extension of aircraft practice, where the redundancy of multiple engines was a tried and proven method of achieving reliability. According to Canright, the panel accepted his recommendations, and he later took advantage of this apparent endorsement to push for his ideas in ARPA planning. Richard Cesaro, long a proponent of high energy fuels for air-breathing engines and rockets, also favored the use of hydrogen-oxygen as propellants for upper stages. He, like Canright, supported the use of multiple engines for large vehicles.[14]

NACA Takes the Initiative

During its 43-year life, the NACA had been content to be a government aeronautical research organization. At the end of World War II, there were three major research laboratories with a staff of about 8000. It contracted a modest amount of research with universities and non-profit institutions. As a non-competing service organization, the NACA was close to and strongly supported by both the military and the aeronautical industry. In the 1950s, the laboratories had started research on missiles; by 1957, such work constituted from a quarter to a third of total research.[15] Among the staff were rocket and space enthusiasts who saw Sputnik as merely an endorsement of what they had been advocating. The majority of the staff, however, were deeply committed to aircraft powered by air-breathing engines, and Sputnik produced an ambivalence. As Bruce T. Lundin, then a division chief at the Lewis Flight Propulsion Laboratory and now its director, saw the situation, "we were divided into two strong camps . . . half were afraid we were going to get sucked into space [research] and the other half were afraid that we were going to get left out." Lundin's view was that the future of the NACA lay in responding to the national need and to "use our unique capability to bring our nation into space. It was either us or the military and I really felt that the United States should go into space as a peaceful civilian activity rather than carrying a sword."[16]

Early in December 1957, Hugh Dryden, NACA's director, summoned the directors and associate directors of the research laboratories to Washington to discuss the future posture of the NACA with respect to space. Abe Silverstein, associate director of the Lewis Flight Propulsion Laboratory, went with Ray Sharp, the director. Silverstein asked Lundin, who had been expressing his views freely, to put them in writing as the Lewis position. Lundin spent a Sunday afternoon writing a paper which Silverstein used, with minor revisions and additions, at the Washington meeting. Dryden opened the meeting with some introductory remarks about the possible courses for the NACA and then asked the research directors for their opinion. The Lewis position was the most enthusiastic response that Dryden got from the Center people. Henry J. E. Reid and Floyd Thompson from the Langley laboratory were not very enthusiastic about building up the NACA to move into space activities. Smith DeFrance from the Ames laboratory was opposed to it, fearing that it would destroy the whole concept on which the NACA was based.[17]

The Lundin-Silverstein paper presented compelling arguments for an active role in space activities. After discussing and discarding two possible roles, the suggested one was:

> . . . a bold and visionary approach based on (a) the importance of space exploration, (b) its urgency and importance to our national survival, (c) the importance of research at this time, (d) our traditional role of leadership in independent aeronautical research, (e) the obvious need for consolidating present Governmental research on space problems into a single agency, (f) our future needs in the way of staff and facilities, and (g) examples of what new knowledge is needed and how the foregoing would provide it.[18]

Following the meeting of the laboratory directors, the chairman of the NACA, James Doolittle, and Dryden took a very unusual step. They invited about 30 research laboratory middle managers—division chiefs in the main—to Washington for cocktails and dinner and an unfettered discussion of what they thought the course of the NACA should be. The 18 December 1957 event, known as the Doolittle dinner by some and the Young Turks dinner by others, was an affair with no holds barred. One or two took the opportunity to berate NACA management for their ultra-conservative position in the past and to air old grievances. Most, however, were with Walter T. Olson, chief of the fuels and combustion division at the Lewis laboratory, when he stood up and made a strong argument for moving boldly into space. Doolittle and Dryden got the message: the younger NACA staff members were enthusiastic for space.[19]

The long established procedure of the NACA, when faced with the prospect of entering a new field, was to form a special advisory committee to look into the matter. This not only obtained the services of prominent and knowledgeable people but formed a basis of support. In November 1957, NACA authorized a special committee on space technology which was organized in January 1958. H. Guyford Stever, associate dean of engineering of the Massachusetts Institute of Technology, was the chairman.* This committee formed seven working groups involving many persons who later became prominent in space activities.

The NACA staff also began its own studies of space technology and desirable research objectives. On 14 January 1958, Dryden released a NACA staff study entitled "A National Research Program for Space Technology." It called for a space effort based on cooperation between government agencies. NACA would step up its space activities, build new facilities, and add to the staff, but would limit its work to basic research. Large vehicles would be flown by the Department of Defense with technical assistance by NACA. This was similar to past arrangements, particularly for research

*Among its sixteen members were Norman C. Appold, the manager of the Suntan project; Wernher von Braun, technical director of the Army Ballistic Missile Agency; and Abe Silverstein, associate director of the NACA Lewis Flight Propulsion Laboratory. Also on the committee were J. R. Dempsey, manager of General Dynamics–Astronautics and responsible for developing the Atlas, and S. K. Hoffman, general manager of the Rocketdyne Division, North American Aviation.

aircraft such as the X-15, and would offend no one. Two days later, the main committee of the NACA met and passed a resolution on space flight calling for a national program involving research in space technology, development of scientific and military space vehicles, and research on higher atmosphere and space phenomena. A cooperative program between NACA, DoD, the National Academy of Sciences, and the National Science Foundation was seen as the best way to implement the program. The resolution emphasized that the NACA role in space was one of coordination and research on space technology requiring expansion of its current activities and called on the special committee on space technology to review needed research and help formulate a program for the NACA.

On 10 February 1958, the NACA staff reinforced the resolution with a report entitled "A Program for Expansion of NACA Research in Space Flight Technology: With Estimates of the Staff and Facilities Required." The report described a program bold in concept and broad in scope.*

The implications of Sputnik for civil space activities were considered by the Congress, and by early 1958, several proposals were pending—including one that would put the space program under the Atomic Energy Commission. None of these suited the administration and in February, President Eisenhower asked his scientific advisor, James Killian, to devise a plan. The result was a recommendation in March, approved by the President, to give the civil portion of the space program to the NACA and strengthen and rename it. On 2 April, less than a week after giving the ARPA the green light on its space plans, Eisenhower sent Congress a bill to establish the National Aeronautics and Space Administration. At the same time, he directed NACA and DoD to discuss current space programs and decide which should be transferred to NASA when it came into being. The Bureau of the Budget thereafter took a very active role in pressing for decisions on the transfer of programs and funding from DoD to NACA-NASA. Thus, in the period from 2 April until NASA was formally in business on 1 October, the new organization had plenty of clout to contend with the ARPA, Army, and Air Force in jockeying for a role in space.

Following the President's 2 April directive, ARPA's Roy Johnson and Herbert York met with NACA's J. W. Crowley, Ira Abbott, and Robert Gilruth to discuss the transfer of programs. It was obvious that purely scientific space programs would be transferred and that reconnaissance satellites would remain with the military, while the disposition of manned spaceflight and launch vehicles was uncertain. Both the military and civilian sides saw a need for large launch vehicles and both included such vehicles in their planning, leaving the precise responsibility for later resolution. It was inevitable, however, that ARPA and NACA were on a convergent course with respect to launch vehicles and propulsion.

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*Among the facilities proposed was one for chemical rockets up to a thrust of 4.5 MN (1 million lb). A smaller test stand equipped with an ejector to reduce ambient pressure at the nozzle for altitude simulation was also proposed. Other facilities included nuclear rockets, pumps, gas generators, and smaller-scale rocket stands. Liquid hydrogen was named as one propellant to be used. These facilities, estimated to cost $380 million, would be built over a 5-year period. The plan also called for an operating budget increase of $100 million annually and more than doubling the staff (to 17000).

During the spring of 1958, NACA's director of research Hugh Dryden sought a strong leader within the NACA staff to come to Washington and help him formulate a civilian space program. He found his man in Abe Silverstein.*

Silverstein (1908-) was a sharp, aggressive, imaginative, and decisive leader. He could be charming or abrasive. He was a hard bargainer at the conference table in technical and management matters but very warm-hearted in personal relationships. He could cast work aside like a cloak and radiate such warmth and empathy for people that those who had felt his lash in a technical discussion earlier could forget their chagrin and respond to him with equal warmth. Many damned his ways but liked the person. He had an uncanny technical intuition, or feel, for the right approach; and those who were dismayed at his methods could scarcely question his judgment. To a casual observer he might appear to be a one-man show, one who would not delegate, or one who liked to participate in all technical decisions, large and small. Yet this is not a complete picture, for Silverstein and his methods were far more complex. In conferences with his superiors or peers, Silverstein was a restrained yet highly skilled proponent for his cause. He was a good moderator or chairman. On the other hand, in conferences on matters where he was directly responsible for the outcome, he was far more direct and aggressive. At the latter, he liked to gather together a group of his subordinates—and, later, contractors—about the conference table and engage in a free-for-all argument over various technical merits or weaknesses of a program or proposed action.

Sometimes he displayed a near-mania for winning the argument, especially on rare occasions when it became rather obvious that he was on the wrong side. Wise associates never pressed him too hard when he painted himself into a corner, for he would never admit it and more time would be lost. Even then his amazing sixth sense in engineering was functioning and absorbing all inputs, and he never followed a bad argument with a bad decision. He respected those who stood up to him and stoutly made a good technical point, but woe to him who made a weak argument, for Silverstein could be relentless. Strangely enough, this dominant personality seldom produced lasting antagonism and did not diminish the growth of strong and competent subordinates; many went on to distinguished careers.†

Silverstein strove always for excellence and he inspired the same in those who worked with him. He attributed this trait to his mother, whom he described as "ideally trained to do space work because she knew the importance of perfection." He eschewed politics, or its equivalent, in management and disdained image building, which is probably why he did not regard himself as a "headquarters-type" person.

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*Silverstein almost lost the opportunity. He recalls that very early in 1958 Dryden asked him to work with him on space planning, but Silverstein refused because he was "not a headquarters-type person." Silverstein, however, was intrigued with the opportunities offered by space and about a month later, approached Dryden with an organizational plan for NACA. He remembers Dryden looking at him coldly and saying, in effect: "Silverstein, I invited you up here to work with me on this thing. If you are willing to come up, fine, otherwise, forget it." Silverstein took the job. Silverstein interview, 29 May 1974.

†Three of the best known are: George M. Low, past deputy administrator of NASA and now president of Rensselaer Polytechnic Institute; Edgar M. Cortright, past director of the Langley Research Center and now an executive in industry; and Bruce T. Lundin, director of the Lewis Research Center.

Fig. 48. Abe Silverstein, director of space flight programs, National Aeronautics and Space Administration, 1958–1960, who had a decisive role in the use of liquid hydrogen as a fuel in the upper stages of the Saturn launch vehicle. (Photo ca. 1955.)

In the spring of 1958, Silverstein transferred to NACA headquarters and began to assemble a staff to help him plan a space program. Others from the three laboratories joined in to help as called upon. By mid-year, personnel at the laboratories and at headquarters were assigned to 11 program elements.* By mid-July, a FY 1960 budget proposal had been prepared by Silverstein, Robert Gilruth, Morton Stoller, Edgar Cortright, and Newell Sanders. The space vehicle portion was $349 million and included vertical probes, 12 small satellites and 3 larger ones for scientific experiments, a satellite for an astronomical telescope, 3 communications satellites, 4 lunar probes, inter-planetary probes, 4 manned space capsules weighing 1140 kilograms each, a 4450 kilogram manned satellite for biological and life science studies, and a winged vehicle for a recoverable space vehicle. The budget called for $80 million for propulsion systems, including $30 million for a single engine of 4.5 meganewtons (1 million lb. thrust), $15 million for nuclear rockets, $12 million for high energy propellants, $15 million for a clustered rocket of 4450 kilonewtons (one million lb thrust), $5 million for solid rockets, and $3 million for solid propulsion components. The budget also called for $26.7 million for a spaceflight staff of 1700 and $50 million for facilities, including a space projects center.[20] On 29 July 1958, President Eisenhower signed H.R. 12575 making it the National Aeronautics and Space Act of 1958. The NACA was absorbed, along with its laboratories and personnel, when NASA officially began operations on 1 October 1958. The new space agency was humming with activity and Silverstein was its chief planner and director under administrators Glennan and Dryden.

*Unmanned satellites: P. Purser, A. J. Eggers, A. Zimmerman, F. O'Sullivan; manned spacecraft: M. Faget, H. Henneberry, Eggers; astronomical telescope: Zimmerman, O'Sullivan, R. T. Jones; meteorology: E. Cortright, M. Stoller, Zimmerman, O'Sullivan; communications: N. Sanders, Stoller; lunar probes: Brown, Stoller; internal power: Cortright, O'Sullivan, von Doenhoff; advanced rockets: A. O. Tischler, G. Thibodaux; range: E. Buckley, Stoller, F. Smith; guidance: Sanders, Stoller; other projects: Zavasky, Cortright.